REMARKS

This amendment is responsive to the Office Action of January 22, 2007. Reconsideration and allowance of claims 1-18 are requested.

The Office Action

Claims 1-5 and 9-12 stand rejected under 35 U.S.C. § 102(e) as being allegedly anticipated by Moriguchi et al., U.S. Patent No. 7,042,215 (hereinafter "Moriguchi").

Claim 1 stands rejected under 35 U.S.C. § 102(e) as being allegedly anticipated by Dale et al., U.S. Patent No. 7,078,899 (hereinafter "Dale").

Claims 1-5 and 9-12 stand rejected under 35 U.S.C. § 102(b) as being allegedly anticipated by Haase et al., U.S. Patent No. 6,400,151 (hereinafter "Haase").

Claims 6 and 8 stand rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Hasse in view of Van Den Brink et al., U.S. Publ. Appl. No. 2003/0122545 or Van Den Brink et al., U.S. Patent No. 6,593,740.

Claims 6 and 7 stand rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Hasse in view of Salerno et al, U.S. Publ. Appl. No. 2004/0260173.

The § 101 Rejection is Remedied by Amendment

Claim 12 has been amended to call for a carrier or memory storing a computer program executable by a computer to perform a method specified in the claim. The term "carrier" is used in the specification at least at page 6, where the example of the carrier being a CD-ROM is presented. The carrier or memory may also be, for example, RAM, ROM, floppy disk, hard disk, or other computer-readable storage media mentioned at page 6. The carrier or memory has a functional interrelationship with an associated computer such that the functionality of the computer program stored on the carrier or memory may be realized by execution of said computer program by the computer.

While functional descriptive material such as a computer program *per se* is nonstatutory, the Interim Guidelines relating to § 101 opine that "[w]hen functional descriptive material is recorded on some computer-readable medium it becomes structurally and functionally interrelated to the medium and will be statutory in most

cases since use of technology permits the function of the descriptive material to be realized." *Interim Guidelines for Examination of Patent Applications for Patent Subject Matter Eligibility*, OG Notices 22 Nov. 2005.

Accordingly, it is respectfully submitted that claim 12 as set forth herein satisfies the requirements of § 101.

Response to the Claim Objections

Applicants understand the claim objections as resulting from ambiguity in the claim language as to whether the "resonance frequency" relates to the magnetic resonance frequency, that is, the frequency of the excited magnetic resonance (for example, about 64 MHz in the case of magnetic resonance acquired from the ^{1}H nuclear species at 1.5T), or whether the "resonance frequency" refers to the frequency of k-space sampling as in the case of variable density spiral acquisitions in which one may have first and second different k-space sampling frequencies.

In the claims, the "resonance frequency" refers to the magnetic resonance frequency. By way of example (and without limiting the scope of claim 1) one possible embodiment on which claim 1 may read is an acquisition in which the acquisition module acquires first magnetic resonance signals corresponding to the ^{19}F nuclear species for a central portion of k-space using a first magnetic resonance frequency (e.g., about 45 MHz for ^{19}F at 1.5T) and acquires second magnetic resonance signals corresponding to the ^{1}H nuclear species for a peripheral portion of k-space using a second magnetic resonance frequency (e.g., about 64 MHz for ^{1}H at 1.5T) which is different from the first magnetic resonance frequency.

The claims have been amended to clarify this by calling for the "magnetic" resonance frequency.

The References of Record

Moriguchi discloses a technique for imaging including fat/water decomposition and spiral k-space sampling. As described starting at col. 9 and referencing Figs. 5a and 5b, Moriguchi teaches collecting spiral data with oversampling in the central region. Different spiral trajectories employ different echo times (TE), and the data acquired with different TE are reconstructed into

corresponding images of different echo time. A B_0 inhomogeneity field map is calculated by taking the phase differences of the different TE images. Water/fat decomposition and k-space data demodulation are performed for the low spatial frequency data, based on the frequencies indicated in the frequency field map.

Applicants find no suggestion in Moriguchi of collecting a central portion of k-space using a first magnetic resonance frequency and collecting a peripheral portion of k-space using a second magnetic resonance frequency different from the first magnetic resonance frequency. Rather, all data appears to be collected at the same magnetic resonance frequency, albeit with a receiver bandwidth large enough to encompass both the water and fat signals. Post-acquisition processing is used to decompose the acquired magnetic resonance data into fat and water images.

It should be noted that the chemical shift between the fat and water signals is small. For example, at 1.5T the fat/water chemical shift is about 3.5 ppm corresponding to about 224 Hz for a magnetic resonance frequency of 64 MHz (i.e., 64,000,000 Hz). The problem faced by Moriguchi is how to separate these closely spaced (in frequency) fat and water signals, which are collected together due to the receiver bandwidth. There is no disclosure or fair suggestion in Moriguchi of collecting one range of k-space samples using the water signal at the water magnetic resonance frequency, collecting a different range of k-space samples using the fat signal at the fat magnetic resonance frequency, and then combining to form a full k-space. Rather, Moriguchi teaches collecting a mixed fat/water signal, apparently at a single magnetic resonance frequency with a bandwidth broad enough to encompass both the fat and water signals, and decomposing this combined magnetic resonance signal into fat and water images by post-acquisition processing.

The citation of **Dale** appears to be the result of the unclear terminology "resonance frequency" used in the original claims. Dale shows sampling of different k-space regions at different k-space **sampling** frequencies (i.e., rates) during magnetic resonance data acquisition. Different k-space sampling frequencies, that is, different rates of data accumulation, may be used in the acquisition of the central and peripheral k-space regions of the claims, e.g. for greater data density, but this is not required by the claims (i.e., the central and peripheral k-space regions may be

sampled at the same sampling rate or frequency). The "magnetic resonance frequency" of the claims is not related to the k-space sampling rate or frequency.

The citation of **Haase** also appears to be the result of this lack of clarity in the original claims. Haase shows acquisition of different regions of k-space using different sequences, as for example in Fig. 1a which shows a sequence i acquiring a central region and a sequence j acquiring peripheral k-space regions. However, Applicants find no suggestion that these different sequences acquire magnetic resonance data at different magnetic resonance frequencies, and it does not appear that the Office Action alleges that such a teaching is set forth in Haase.

The two **Van Den Brink** references and the **Salerno** reference are cited merely to show that it is known to acquire electron spin resonance, non-proton resonance, and hyper-polarized non-proton resonance. There is no allegation in the Office Action that these references teach acquiring two such resonances having different magnetic resonance frequencies to fill different parts of k-space, with the different k-space portions combined to form a full k-space.

The Claims Distinguish Patentably Over the References of Record

Claim 1 calls for a magnetic resonance imaging system comprising an acquisition module for acquiring first magnetic resonance signals for a central portion of k-space using a first magnetic resonance frequency and for acquiring second magnetic resonance signals for a peripheral portion of k-space using a second magnetic resonance frequency different from the first magnetic resonance frequency, a data module for combining first k-space data corresponding to the first magnetic resonance signals and second k-space data corresponding to the second magnetic resonance signals to form a full k-space, and an image module for generating an image by transformation of the full k-space to image space.

The references, alone or in combination, do not disclose or fairly suggest a module for acquiring first magnetic resonance signals for a central portion of k-space using a first magnetic resonance frequency and for acquiring second magnetic resonance signals for a peripheral portion of k-space using a second magnetic resonance frequency different from the first magnetic resonance frequency. While some references such as Haase disclose collecting data from the central region of

k-space in a different manner than from the periphery of k-space, these references do not disclose or fairly suggest doing so at different magnetic resonance frequencies.

Moreover, the references alone or in combination do not disclose or fairly suggest a data module for combining such central and peripheral k-space data acquired at different magnetic resonance frequencies to form a full k-space, operating in conjunction with an image module for generating an image by transformation of the full k-space to image space. The first and second magnetic resonance signals are acquired at different magnetic resonance frequencies, and hence are generated by different sources, such as in one non-limiting illustrative embodiment ^{19}F nuclei generating the first magnetic resonance signals and ^{1}H nuclei generating the second magnetic resonance signals. It is in no way apparent from the references of record that central and peripherial k-space samples acquired from such different sources would be combinable to form a full k-space that can be transformed into a useful image.

Claim 11 calls for a magnetic resonance imaging method comprising: acquiring first magnetic resonance signals for a central portion of k-space using a first magnetic resonance frequency; acquiring second magnetic resonance signals for a peripheral portion of k-space using a second magnetic resonance frequency different from the first magnetic resonance frequency; combining the first k-space data corresponding to the first magnetic resonance signals and the second k-space data corresponding to the second magnetic resonance signals to form a full k-space; and generating an image by transformation of the full k-space to image space.

The cited references do not disclose, alone or in combination, acquiring central and peripheral portions of k-space with magnetic resonance signals of different magnetic resonance frequencies. They further do not disclose combining the k-space samples to form a full k-space that is transformed to form a useful image

Claim 12 calls for a carrier or memory storing a computer program executable by a computer to perform a method comprising acquiring first magnetic resonance signals for a central portion of k-space using a first magnetic resonance frequency, acquiring second magnetic resonance signals for a peripheral portion of k-space using a second magnetic resonance frequency different from the first magnetic resonance frequency, combining the first k-space data corresponding to the first magnetic resonance signals and the second k-space data corresponding to the second

magnetic resonance signals to form a full k-space, and generating an image by transformation of the full k-space to image space. Again, the references alone or in combination do not disclose the novel combination of acquiring central and peripheral portions of k-space with magnetic resonance signals of different magnetic resonance frequencies, combining the k-space samples to form a full k-space, and transforming the full k-space to form a useful image.

Claims 13-18 are added claims that call out certain embodiments in which the first and second magnetic resonance frequencies are substantially different. The subject matter of these claims are supported in the original specification at least at page 3 lines 21 through page 4 line 34.

In Haase, the fat and water signals are both from the same nuclear species, namely the ^{1}H nuclear species. The difference in frequencies is due to the chemical shift, i.e. due to the different chemical environment of the ^{1}H nuclear species in the respective fat and water matrices, and is miniscule, typically being of order a few parts-per-million (ppm) to perhaps a few tens of ppm. As a result, the approach of Haase can acquire both the fat and water signals as a single integrated signal using a magnetic resonance receiver having a bandwidth encompassing both the fat and water signals. A conventional MR receiver satisfies this bandwidth requirement since the chemical shift is small. As noted previously, unlike Haase the present claims call for acquiring two different magnetic resonance frequencies from the central and peripheral k-space regions, respectively.

Claims 13-18 present further distinctions over Haase. The magnetic resonance frequency for a given static (B_0) magnetic field is proportional to the gyrometric ratio. As noted in the present application, for example, the gyrometic ratio for the ^{19}F nuclear species is 70% less than that of ^{1}H, and 25% for ^{13}C and ^{129}Xe. (Application at page 1 line 25). These differences translate to correspondingly large differences in magnetic resonance frequency of 25% or more, corresponding to differences in magnetic resonance frequency in the MHz to tens of MHz range. In contrast, the fat/water chemical shift for the ^{1}H magnetic resonance at 1.5 T is about 3.5 ppm which corresponds to about 224 Hz (that is, 0.000224 MHz).

Accordingly, even if Haase were viewed as showing some combination different k-space regions acquired using the fat and water signals, respectively (a view

with which Applicants do <u>not</u> agree), such a result would still not provide the skilled artisan with a reasonable expectation of success in implementing the apparatuses of claims 13-15 or the methods of claims 16-18. Combining different k-space sampling regions acquired using two different chemically shifted magnetic resonance signals with magnetic resonance frequencies differing only by the chemical shift of about 3.5 ppm is not comparable with combining central and peripheral k-space regions acquired using different multi-nuclear magnetic resonance signals at nuclear magnetic resonance frequencies differing by amounts that are orders of magnitude larger than the chemical shift.

For at least the foregoing reasons, it is respectfully submitted that claims 1-18 as set forth herein distinguish patentably over the references of record.

CONCLUSION

For the reasons set forth above, it is submitted that claims 1-18 (all claims) distinguish patentably over the references of record and meet all statutory requirements. An early allowance of all claims is requested.

In the event that personal contact is deemed advantageous to the disposition of this case, the Examiner is requested to telephone Thomas Kocovsky at (216) 861-5582.

Respectfully submitted,

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